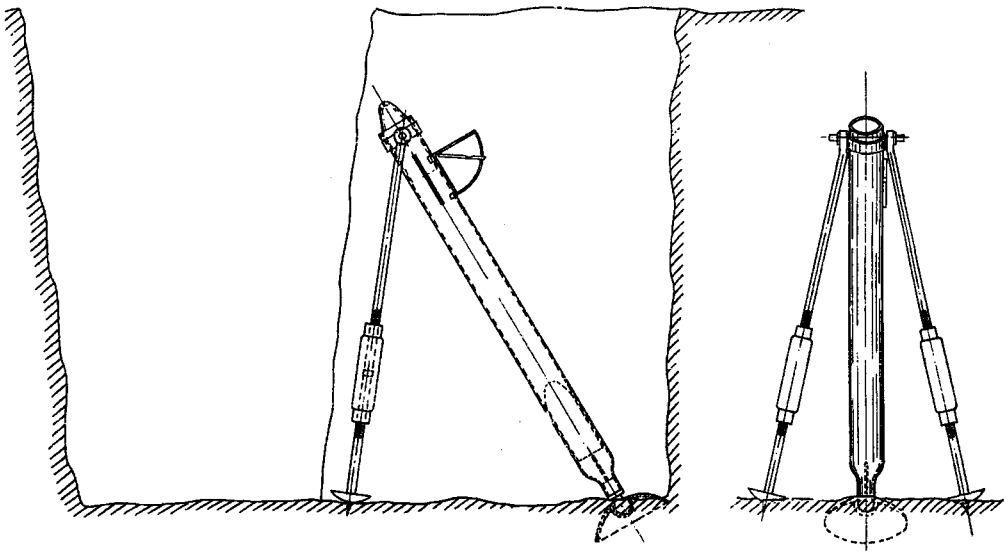
CHAPTER 8

A Tale of Two Stokes – Mortars 1915–18

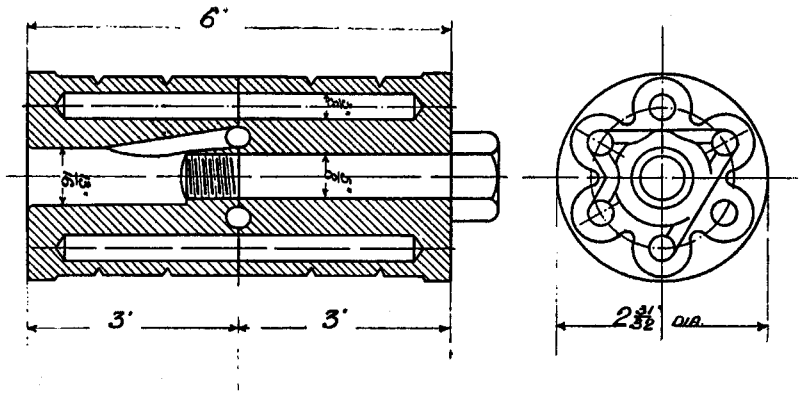
If there was one outstanding invention of the war, it was the Stokes mortar. This remarkably simple weapon was not only vastly superior to any other mortar but it was cheap to make and significantly increased the firepower available to the infantry. Like Mills, Stokes had no experience of weapons before he set about designing the mortar but whereas Mills found little difficulty in getting his grenade accepted Stokes met considerable resistance to his design. This was partly because his inexperience led him down blind alleys and partly because of the changing responsibilities of the various research and development departments and the creation of new ones. It meant that no single department had sole jurisdiction – there were too many cooks. It was to prove a long hard road for Stokes before the mortar was finally accepted. The poor performance of the early designs of the ammunition did not make it any easier.

Wilfrid Stokes and his mortar, demonstrating its lightness and the ease with which it could be carried. Initially, Stokes crews carried their mortars in this fashion but they were too easily picked out by German observers, who quickly brought down a barrage on them. (The Times History of the War)

In late 1914, when Frederick Wilfrid Stokes learned of the Army's desperate need for trench mortars, he was fifty-four years old and chairman and managing director of an engineering company in Ipswich called Ransomes & Rapier, which made very unwarlike machinery such as cranes, pumps and gas cylinders. Although he knew nothing about guns, like so many leading inventors of the time, he was a good engineer who knew how to solve engineering problems. In 1918 he claimed that it was exactly because of his lack of knowledge of things military that he was able to come up with such a simple design. He abhorred the tendency towards increasing complexity and advocated the setting up of a new department, the 'Simplification of Designs Department' which if it did its job could reduce production times and costs. Needless to say, no one took him seriously. But he had a point. It was partly because his design was so simple that he had so much trouble getting



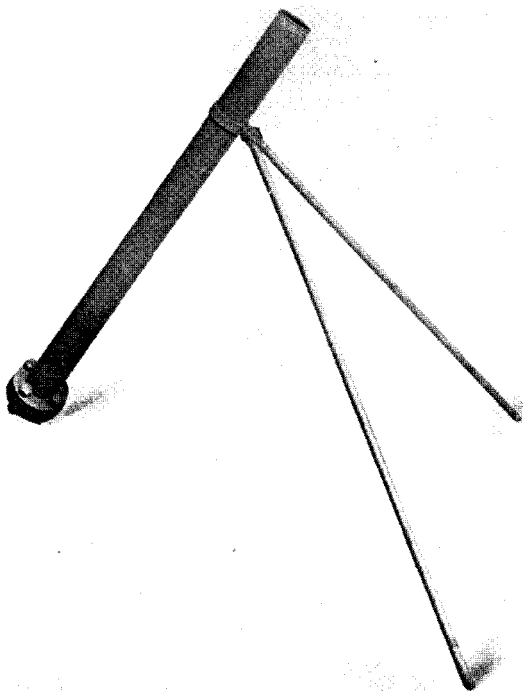
Wilfrid Stokes's original drawings for his mortar which he sent to the War Office in December 1914. (T 173/453)



The bouncing bomb originally intended to be fired from the mortar. Note the six explosive compartments, the central propellant compartment and the connecting passages. (T 173/453)

it accepted, although in fairness to the departments that dealt with him, the early mortar and ammunition were decidedly imperfect. By the end of the war, his mortar was held up as the epitome of simplicity and effectiveness in weapon design.

Stokes was asked to design something to help ease the Army's predicament by a journalist friend who had visited the Front. In a remarkably short time he came up with a design of a simple length of tubing supported on two adjustable legs which fired a rather more complicated shell made of cast iron. This consisted of seven chambers, one of which housed the propellant,



The first mortar made by Wilfrid Stokes which he used for his initial tests. (T 173/453)

the other six containing explosive charges. The idea was that the shell should land in an enemy trench where one of the chambers would detonate and send the shell to another location until the next one exploded sending it to another and so on until the six chambers had all been fired. It could have been called a rebounding bomb. The tube or barrel had an integral firing spike in the base which detonated the propellant when the shell slid down the barrel and hit it. In this way, the mortar could fire as many shells as could be slid down the barrel, one after the other. The recoil was absorbed by a bowl of cast iron at the base of the barrel.

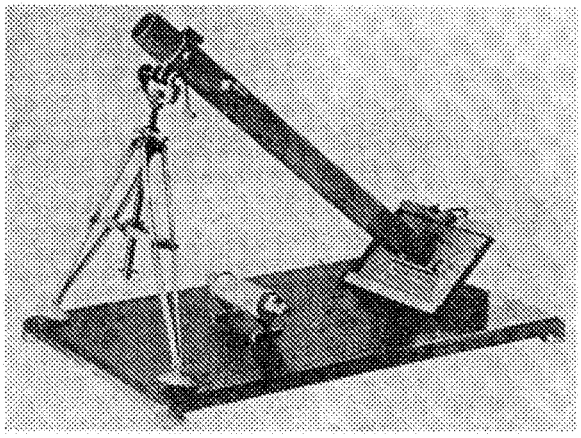
He sent the design to the War Office in December 1914 who thought it was unworkable and turned it down. Undeterred, he went back to the drawing board and 'acting on the courage of my own conviction . . . I had a primitive gun made. At the works of Messrs. Ransomes and Rapier, Ltd, Ipswich, out a piece of drawn tube, and a shell out of a piece of bar.' A trial firing shot the first shell to a greater distance than he had anticipated and he 'nearly took refuge in a cottage'. Encouraged by the results, he went back to the War Office and a trial was arranged at the Shoeburyness Test Centre for 30 January 1915. However, this did not go at all well. Accuracy and range were unacceptably poor. The Director of Artillery turned down the mortar after a second trial the following month.

Stokes remained optimistic, though, and concluded that although the concept was sound he had much to do to turn it into a workable weapon system. He decided that the 'bouncing cracker bomb' was not such a good idea after all after trying different approaches, none of which succeeded, and proceeded to design a more conventional shell. He was also told that the War Office was not interested in a bouncing bomb (although it would change its mind in 1918 when it discovered the Germans had one). Further, he realized that his knowledge of propellants and explosives was so limited that using black powder for both was the only way forward, although he soon moved on to experimenting with high explosives. He had to learn as he went.

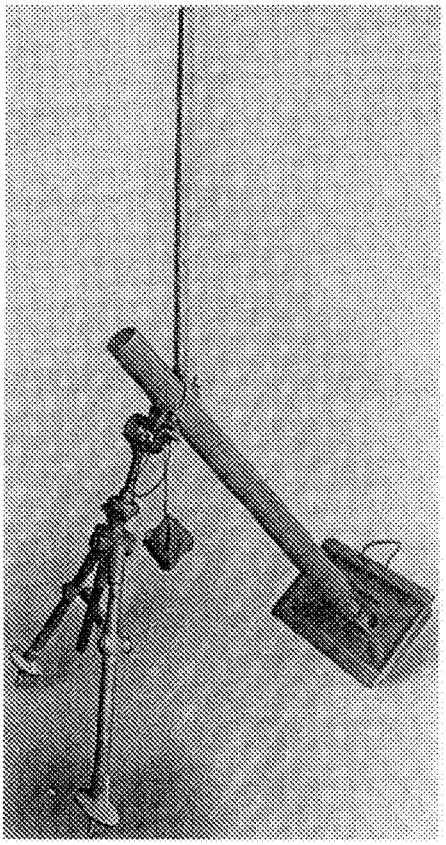
Over the next few months, he devoted his weekends to developing the mortar and shell, conducting trials of his own to test his modifications. The mortar itself was easier to improve than the shell, which was something of a headache, but he was determined to produce a weapon and shell that would be of real value to the war effort. As far as the mortar was concerned he had four objectives:

1. Simplicity in manufacture.
2. Simplicity and speed in firing.
3. Lightness and portability.
4. Quickness and ease in setting up, and change of objective.

Initially, the barrel was made by boring a steel tube but the quicker process of cold drawing was found to produce accurate barrels. The bottom end was bottlenecked with machinery used in the manufacture of gas cylinders, readily at hand in Ransomes & Rapier's works. The legs on the first production mortars were a pair of inverted A-frames with elevating and traversing gear although his earliest designs had even simpler strut-like supports that were quite flimsy in comparison to the legs the mortar ended up with in the field. The early A-frames proved to be rather difficult to set up properly in the field and liable to damage when set up incorrectly, so after about 2,000 mortars had been produced a heavier tubular design replaced them. When the war ended, a refinement of nested springs was in development to absorb some of the recoil and prevent damage to the mortar if it had been badly set up.



This example of the first service pattern of the mortar is set on a display stand. The first type of leg is clearly visible. Note the shell with the fuse facing the camera and the shell-release device on the side of the barrel near the muzzle. (T 173/453)



The second service pattern with stronger legs. The shell-release device has been omitted. Note the periscope and canvas muzzle cap hanging from the elevating gear. One of the three depressions in the base plate can be seen; the middle one is occupied by the breech end of the mortar. These allowed some degree of traverse. (T 173/453)

The design of the striker proved to be more difficult than Stokes had first thought because as he put it in 1918 'I started off on the wrong track'. Originally, the striker was pointed so that it struck the propellant cartridge in the centre of the shell, the gases blowing past it. However, fouling from the remnants of the cartridge was severe and there was no chamber in which the propellant could be burned efficiently. He tried a square-ended striker with a completely enclosed chamber for the cartridge. The results were disastrous. The shell split and the barrel nearly burst. After that, he made pressure calculations first to check if what he was proposing was safe.

With the calculations he now made, he determined the correct thickness of the cold-drawn barrel to withstand the pressure generated by the propellant in the expansion chamber at the breech end. The chamber was important to the operation of the mortar. The propellant he eventually chose was ballistite and this could generate a pressure of more

than 40 tons per square inch when it completely filled a chamber. The expansion chamber reduced the pressure to about 1.75 tons per square inch for a 3 in bore. He tested the calculations with a barrel that was reduced to a thickness of 1/16 in for 2 ft. Firing ten rounds from it proved that it suffered no deformation.

After much trial and error, Stokes at last came up with a workable design of shell. He had a lot of trouble with the shell tumbling in flight because it would not stabilize nose first, a problem that was caused by the unrifled barrel. Since he did not want to put rifling in it, he put fins on the shell. Although this worked, the design was for some reason unacceptable to the War Office so Stokes had to start again. The final design was a simple cylinder, originally made of cast iron but quickly changed to steel tubing which contained about three times as much explosive as an 18-pounder shell. The ends of the cylinder were screwed in place and the diameters of these had to be precision machined within very close tolerances to ensure that windage losses remained consistent.

To overcome the fouling problems with the original propellant cartridge, Stokes designed a cartridge chamber for the shell that projected downwards from the rear of the shell and which was vented to allow the gases to escape and propel the shell. The size, number and position of holes had to be determined empirically and it soon became apparent that the cartridge holder had to be made from high-quality material to avoid splitting when the cartridge was fired. The propellant was contained in a shotgun cartridge case. Various cases were tried and he eventually selected Eley as the best (the 3 in mortar used a 12-bore while the later 4 in used a 4-bore). Having selected ballistite, a combination of nitroglycerine and nitrocellulose made by Nobel, as the most suitable propellant and having determined the right amount of fulminate of mercury for the initiating cap, Stokes was dismayed to discover that on one day things would go well while on the next he could not reproduce the same results. He made adjustments to correct the faults only to find that the following day the same problem reappeared. This phenomenon bedevilled him for some time before he discovered that the unpredictable variations were due to changes in temperature.

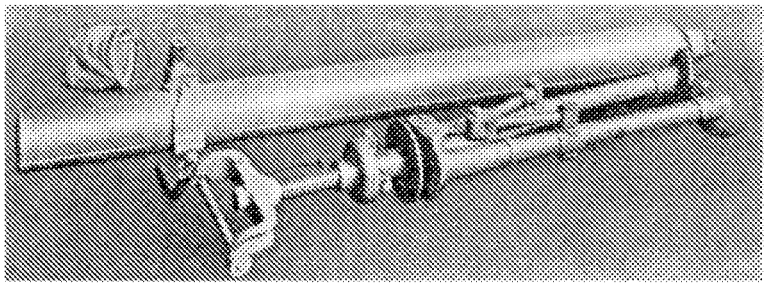
In the meantime, he had shown the improved mortar to the War Office once more and trials were held in March and April at Woolwich. These were reasonably successful and all that remained was approval from the Deputy Director of Artillery, Major-General Bingham (this was before he joined the Design Department of the Ministry of Munitions). Although GHQ had submitted repeated requests for a new mortar and the Stokes fitted the bill, Bingham told Stokes that the Army already had enough mortars and did not need a new one. He refused to sanction its manufacture. It seemed that all the time and money that Stokes had invested in his mortar (he had spent about six months and £3,000 on its development) had been for nothing.

However, all was not lost. By now, the Ministry of Munitions had been created and it decided to take an interest in the mortar, arranging yet another trial. At this latest demonstration, Stokes met Captain Sutton, RE, who had returned wounded from the Dardanelles but with the specific instruction to find a suitable mortar for use in the peninsula where the mortar situation was dire. The Stokes mortar impressed him and he persuaded Lloyd George and Churchill to attend another demonstration on 30 June. They too were impressed with it and Lloyd George agreed to the manufacture of the Stokes mortar and its shells. There was one proviso, however. All the wrinkles had to be ironed out first so that it worked perfectly.

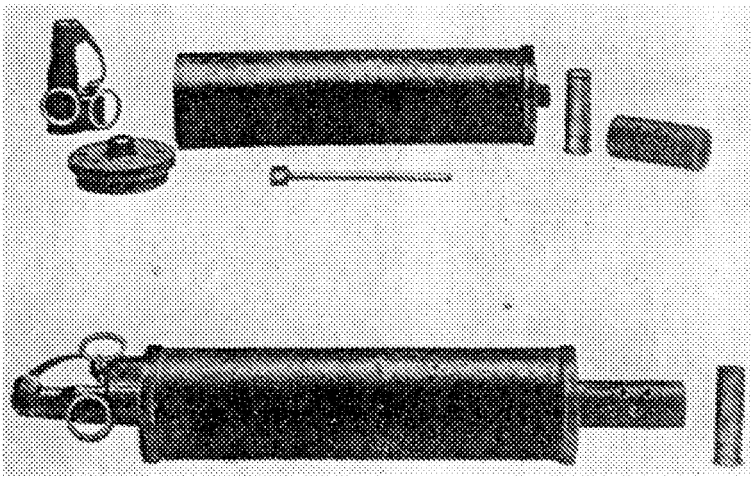
Even Stokes had to admit, it was still far from perfect. For one thing, the shell's fuse was not giving the best performance. A solution to the fuse problem was suggested by a Captain West of the Royal Engineers (who may have been the same West who invented the Spring Gun): why not use the Mills fuse and lever mechanism. Stokes agreed. The time fuse that was eventually used was an adaptation of the Mills mechanism but it went through at least three modifications before an acceptable fuse was developed.

In August the mortar underwent another series of trials, this time for the Ordnance Committee. They agreed that it was better than the 3.7 in mortar but were unhappy with the shells, which still needed improvement. Nevertheless, Lloyd George instructed that 200 mortars should now be manufactured. To the displeasure of the Trench Warfare Department, Stokes proceeded to organize about forty companies, including Ransomes & Rapier, to fulfil the order. Somewhat pointlessly, the department countermanded this and placed the orders with firms of its own choice. The official sanction to make the mortar came from the Ordnance Board in September. However, Munitions Design decreed that 1,000 shells had to be successfully fired from six Stokes mortars before it could be used on operations. It was not until yet more trials had been completed in March 1916, this time to look at its rapid-fire capabilities, that the mortar at last became operational and even then only smoke rounds were fired from it.

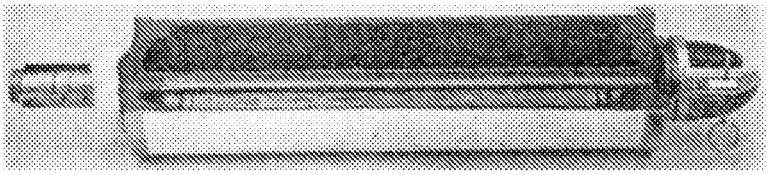
It was firing high explosive before too long, which it could do at a considerable rate – between twenty and thirty rounds a minute. The limiting factor was the skill of the loader and the supply of ammunition. Robert Graves recalled the battalion trench mortar officer



The legs have been removed for transport. (T 173/453)



High-explosive 3 in round. The top view shows the components including the cartridge and its holder, detonator and fuse mechanism. The latter is a modified Mills mechanism. Note the holes in the cartridge holder. (T 173/453)

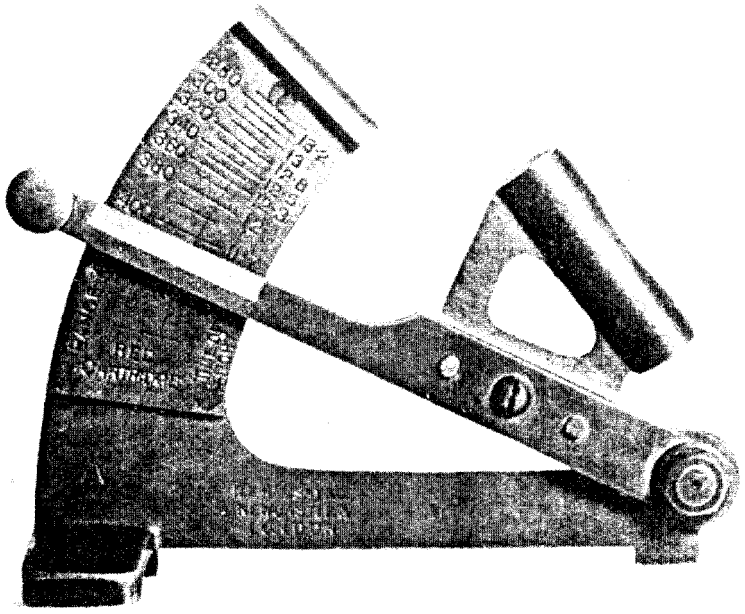


A 4 in gas shell sectionalized. Note the propellant increment ring around the cartridge holder. (T 173/453)

enthusing over his two new Stokes mortars which he described as 'beauties', explaining that he could 'put four or five shells into the air at once'. Yet the first Stokes did not always perform as expected. During a raid by the Royal Welch Fusiliers in April 1916, the two mortars detailed to silence a machine-gun developed faults and failed to fire more than a few rounds. But on most occasions the Stokes did sterling work in destroying enemy machine-guns and trench mortars. Frank Richards was full of praise for them because of their high rate of fire and condemned the 3.7 in mortars they replaced as 'clumsy' and more dangerous 'to ourselves than they were to the enemy, having a short range and the shell often bursting in the gun'.

The original Stokes had a system whereby it was fired in the same way as the existing service mortars, in other words, slowly and with a lanyard. It was actually fitted with an arrangement at the muzzle so that the shell did not drop on to the firing pin until the lanyard was pulled. This was slow and tedious, not to say unnecessary, but it had been imposed on the mortar for reasons of safety. However, the thinking behind this had the existing service mortars in mind and failed to take into account the entirely different firing method of the Stokes. The system was quickly dispensed with as it became apparent that it was superfluous.

After the 3 in Stokes entered service, very little was changed apart from the legs and it remained much the same at the end of the war as when it was introduced in 1916. Later, a 4 in model was introduced but the 3 in was the more common type. Improvements were made to the elevating and traversing gear to make the Stokes more accurate and stronger and a deflection scale was added so that correct deflections could be read for every 5° of elevation. This was necessary because altering the elevation affected the traverse. The shell also remained little changed apart from slight modifications that became necessary to help production and to correct minor defects that field use threw up. The propellant charges consisted of three 12-bore cartridges with different fillings which gave ranges of 50–430 yd. The maximum range was achieved with the red cartridge but it caused a lot of prematures and



A view of the Stokes clinometer showing the long-range settings. Range in yards and time of flight are marked. The manufacturer's name is also visible – N.E. Hamsay of Newcastle and London. (T 173/453)

A Portuguese Stokes crew near Neuve Chapelle, June 1917. Note the wooden bed for the base plate, introduced to prevent the mortar sinking in soft ground. (IWM)

casualties were common so it was withdrawn. However, Captain Newton of the Second Army Workshop found a remedy. He used a 12-bore cartridge of propellant as a primary charge and supplemented it with a ring of additional ballistite placed round the cartridge holder. The ring was made of fabric and had to be kept dry.

Not only did this solve the problem of prematures but it increased the range by more than 60 per cent so that the 3 in Stokes could throw a shell to 700 yd. The ballistite ring was later replaced by cordite rings which extended the range to 800 yd. Unfortunately, the cordite had the disadvantage of producing a considerable flash as well as blast at the muzzle. Moreover, there were difficulties in getting hold of cordite of the right thickness; it was essential that the propellant did not burn too quickly otherwise the pressure in the barrel would become too great. To get round these flaws, experiments were conducted with EC3 sporting powder which was flashless and gave little blast. Photographic celluloid was used to contain the powder but it was not entirely satisfactory as it did not burn consistently, which caused erratic shooting. This had not been resolved before the war ended.

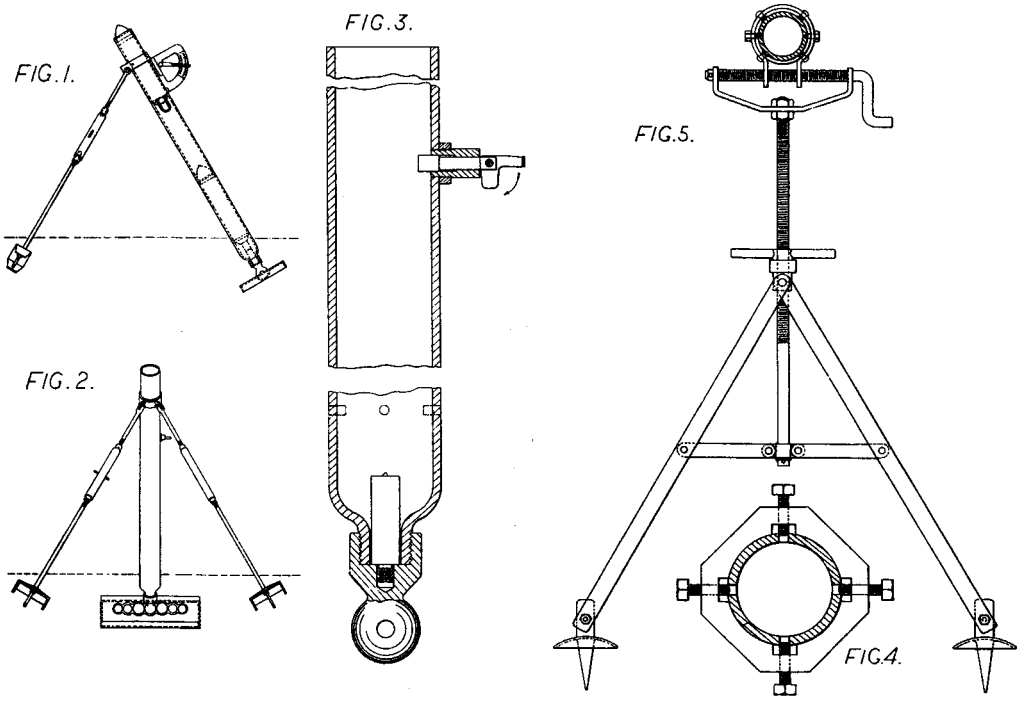
By mid-1917 the Stokes had surpassed the poor reputation of the early mortars and was being hailed as a battle-winning weapon by GHQ which issued notes about its accomplishments to encourage similar endeavours. 'Employment of 3-inch Stokes Mortars in Recent Fighting' issued in June 1917 (which could mean that it referred to Arras in April or the more recent battle at Messines) gave several examples. A preparatory barrage of 4 minutes prior to a brigade attack had the objective of destroying five machine-guns at 550 yd range for which two ballistite rings with a green cartridge were used. 'The machine-guns did not fire and the attack was successful.' On another occasion, a party of Germans was seen to be setting up a light mortar. A Stokes fired on them and the second round made them retreat, leaving the mortar exposed. The Stokes fired eight rounds for registration and then proceeded to destroy the mortar with three direct hits. The Stokes was even used to shepherd potential prisoners forward from their trenches so that they had no choice but to surrender.

By the middle of 1918 another increase in range was needed and Newton proposed putting tail fins on the bombs, which must have struck Stokes as rather ironic considering that his proposal to use tails had been turned down in 1915. Although the tails increased the range to 1,800 yd, the accuracy left a lot to be desired. In the end, a tailed bomb of a French design was adopted. Following this, experiments with lighter bombs (7 lb as opposed to 11 lb) led to another French bomb being adopted. This was a streamlined Brandt design (UK patent 131,258) used with the company's pneumatic mortar which was fired with compressed air. This was in service with the French Army. The Brandt mortar shell made use of the incremental ring charges and it was possible for the Stokes to fire a Brandt shell to 2,500 yd. The French charges did not produce accurate shooting, though, so a British charge was developed. The Brandt shell did not enter service before the close of hostilities.

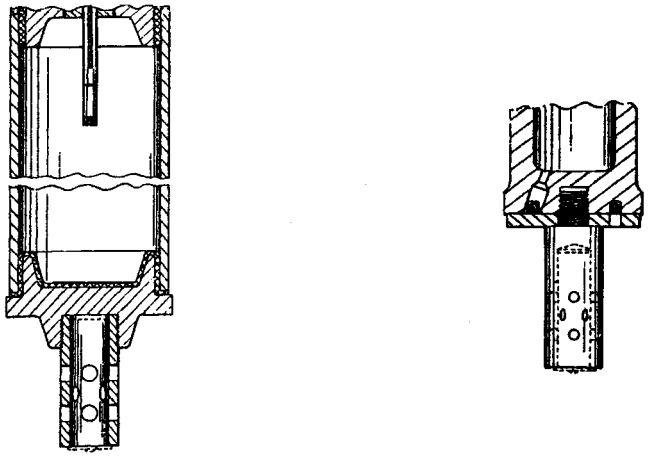
Six months after the introduction of the 3 in Stokes, the pistol head igniter with Bickford fuse being used on the shells was still giving a lot of trouble. Prematures and blinds were far too common so when it was declared obsolete it was replaced with an all-ways fuse (No. 146) but this turned out to be dangerous to handle and it did not perform well. Improvements to the fuse reduced the prematures to an acceptable level but blinds were still occurring too often and by the end of the war the problem had still not been entirely eliminated.

On 27 July 1915 Stokes filed two patent applications, one for the mortar, the other for the shell with the cartridge in the base, using the same firm of patent agents as Thring was to use for his grenade gun. The patents were subsequently granted as 10,882/15 and 10,883/15. On 11 January 1916 the Ministry of Munitions offered Stokes £10,000 as a one-off payment for a licence to manufacture the mortar and its ammunition. Moreover, he was assured that the sum would not be reduced by the special tax on war profits; if he had to be pay the tax the Ministry would refund the money. The Ministry also offered a royalty of £1 per mortar and 1*d* (approximately 0.4p) per shell manufactured. The terms also allowed Stokes to apply for foreign patents provided publication came after the end of the war (which, in effect, meant that he would have to wait until after the war to file any foreign application) and permitted the mortar to be manufactured by or for Allied governments, provided the UK gave prior approval. Two days after the offer, Stokes accepted.

The Stokes formed the basis of a new medium 6 in mortar introduced in mid-1917 to replace the 2 in medium which was far from reliable as the ammunition was prone to prematures. In addition, its range was inadequate. This new mortar was a development of the Stokes undertaken by Newton who was now at the Trench Warfare Department, although he embarked on its development while still at the Second Army Workshop. He set out a list of eight requirements that the new mortar had to satisfy.



Left: *The drawings from Stokes's first mortar patent, 10,882. Note the cartridge holder on the base of the shell in fig. 1 and the shell-releasing device illustrated in figs 2 and 3. Note also the firing pin and that it can be removed with the base cap.* Right: *Legs for the mortar as illustrated in 10,882.*



Left: *Stokes mortar bomb as illustrated in UK patent 10,883. The propellant cartridge holder is screwed into the base and is pierced with several holes to allow the gases to escape. Note the thickness of the base. The cartridge is the dotted line in the holder.* Right: *An alternative shell base described in 10,883. This is a time-fused shell. The hole on the right-hand side circles the base and enters the explosive cavity as shown on the left-hand side. This passage contains the time fuse which is ignited by the flash of the propellant on discharge.*

1. There must be no flash and little noise when fired.
2. High rate of fire.
3. The weight of the weapon must be at a minimum.
4. The range should be as great as possible, the weight of the barrel being the limiting factor.
5. The bomb had to convey the maximum amount of explosive.
6. The bomb had to be capable of demolition work yet destroy wire and personnel without making big craters.
7. The fragmentation of the bomb should be such that the danger zone was confined to an area occupied by the enemy and no splinters should be projected back into friendly troops.
8. The mortar and its ammunition should be easy to manufacture and easy to use in the field.

A 6-inch diameter for the barrel was a compromise that would meet these criteria, capable of delivering 12 lb of explosive. A 6-inch bomb would have better penetration characteristics than the 2-inch toffee-apple bombs, which were about 9 inches in diameter. Providing the bomb with a modified 107 Newton fuse ensured that instantaneous detonation would destroy wire entanglements without producing craters. Gun cotton yarn was chosen as the propellant although this was not a popular choice but there were very few prematures or accidents using this propellant. By the end of the war, 38,000 6 in mortar rounds were being manufactured every week.

As far as speed of operation of the mortar was concerned, Newton realized that the obvious answer was to use a system similar to that of the Stokes. Moreover, this reduced the number of working parts to a minimum which in the muddy conditions of the trenches was an important consideration; mud was a serious problem with early mortars, fouling the firing mechanisms. Newton did not adopt the striker and cartridge-holder method of firing the bombs of the Stokes but elected to use defective small arms cartridges fitted with integral strikers and a flat stud in the barrel to arrest the bomb's passage down the barrel, similar to that used on the old 3.7 in and 4 in rifled muzzle-loaded mortars. The use of the cartridges helped to prevent misfires and was cheap whereas the cartridge holder used on Stokes shells had to be machined from steel and drilled with holes. The cartridges contained gun cotton yarn dusted with black powder.

Newton chose to adopt a slightly different system from Stokes because of the occasional difficulty created by the striker being slightly eccentric which caused misfires. If the percussion cap was eccentric this produced the same problem. Because of this, the striker used by the 6 in was later adapted for use with the 3 in and 4 in Stokes. He also devised a safer method of dealing with misfires which was a 'very unpleasant business' especially for an inexperienced crew. Instead of having to remove a misfire by hand, he designed a 'miss fire plug through which a slow burning time fuze could be inserted'. By lighting the fuse, a misfired round (often caused by a defective cap) could be ejected safely.

Newton discovered that by adding slow-burning cordite or smokeless powders to the gun cotton yarn contained in the cambric bags, the range could be doubled from 1,000 yd to 2,000 yd without having to increase the thickness of the barrel; it was ultimately thickened slightly. It was through this discovery that Newton had the idea for the ring charges later adopted for the Stokes, increasing its range from 300 yd to over 800 yd, without having to make any alterations to the mortar. Having proved successful with the Stokes, the same principle was applied to the 9.45 in mortar. It helped to solve the problem of fizzles while improving the

accuracy at 1,100 yd from 93 yd at 45° elevation to about 12 yd. This improvement was possible because of the increase in consistency of propellant gas pressure.

The additional charges for the 6 in were contained in cambric bags rather than rings as the design of the bomb would not allow rings to be placed round its tail. Four bags of gun cotton were used and up to four bags of cordite could be added. As with other mortars, the 6 in produced a muzzle flash which could be a nuisance when trying to conceal a position from the enemy. Guy Chapman noted the 'violet flame of a 6 inch Stokes repeated time and time again' as it fired in the twilight of early evening. The first 6 in Newton mortars (also known as the Stokes-Newton) were cast in brass from used cartridge cases, then machined. Newton also experimented with adding rifling using machinery made locally (this was while he was still at the Second Army Workshop) but he abandoned the idea when it became apparent that it was an unnecessary complication which would inevitably slow down production. Its rate of fire was eight rounds a minute.

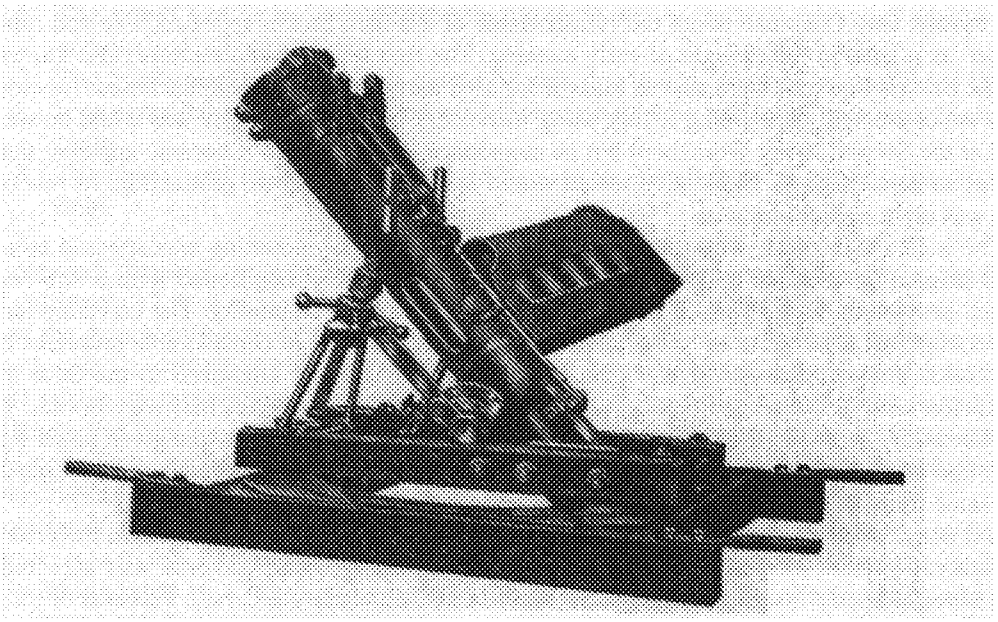
The increase in range with the extra charges meant that the mounting was stressed more than originally intended and its wooden platform had to be strengthened with a sub-bed which provided a larger surface area and increased the mortar's stability. The elevating and traversing gear also had to be strengthened. These were a source of considerable problems in the field. They consisted of two guys of threaded steel bolts, anchored to the base by extension bars. The threaded bolts could be screwed into open receivers that were hooked to the barrel. By screwing the bolts in or out the mortar could be trained on to a given target but they had an unfortunate tendency to break and had to be replaced by stronger ones. At much the same time, the method of attaching them to the barrel was changed.

But none of this did anything to remedy a basic flaw in the gear: if the barrel was traversed, the elevation was altered and if the elevation was changed the traverse was affected. Moreover, the scale inscribed on the barrel was not mathematically accurate. This was of little consequence when the ranges were 1,000 yd or less but as soon as the extra charges increased the range it became a serious problem. Vickers and Armstrong Whitworth were asked to find a solution but one was not forthcoming before the end of the war. There was also disagreement over the worth of any change to the mortar that would make it more complicated.

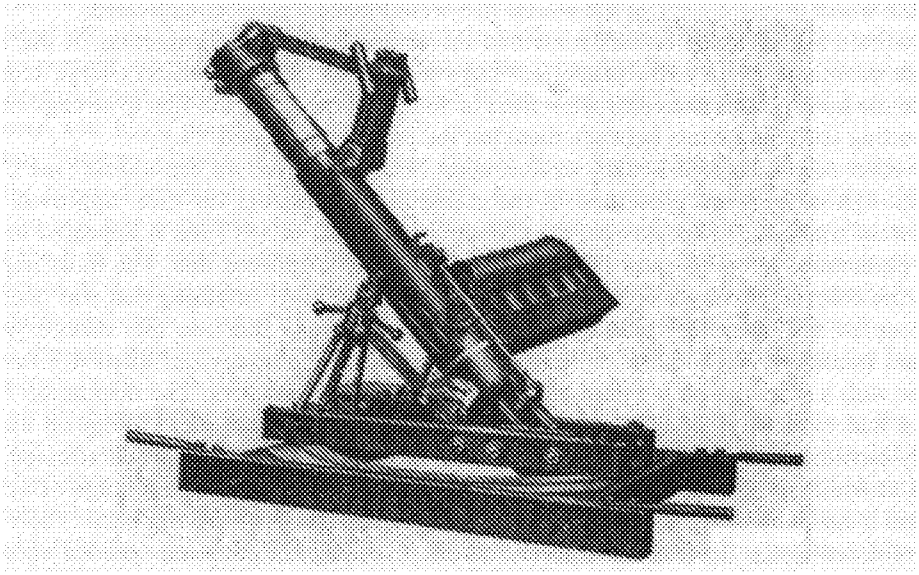
Newton's 50 lb finned bombs remained in service from the introduction of the mortar despite problems when extra propellant bags were used. The increased charge tended to buckle the tail. Various remedies were tried including corrugating the fins to strengthen them and putting stiffening struts between them but the problem persisted.

No other mortar entered British service, apart from the Livens oil can mortar (*see* Chapter 9) although many were presented to the research departments for their approval. Some underwent trials. A French design, the Claude was trialled in 1917 but it appeared to suffer from prematures although later French trials at Bourges disproved this. The most important of all the criteria that any mortar had to satisfy was simplicity. Anything that was deemed to be complex did not really stand a chance. Many weapons fell into this category, rifled mortars included. A company called the Midland Gun Company designed a 3 in trench mortar with a rifled barrel which it called the BEF Trench Howitzer. The inspiration for this device had evidently been the many unexploded trench mortar shells lying on captured enemy territory due to faulty ammunition and careless gunners who, when stressed, often failed to withdraw the safety pins before firing. It was designed to have a range of 1,500 yd and had a specially designed, muzzle-loading shell with a copper driving band. There was a foolproof detonation device which decreased the percentage of duds and speeded up the rate of fire. It was alleged to be capable of firing thirty rounds a minute. The Munitions Inventions Department turned it down.

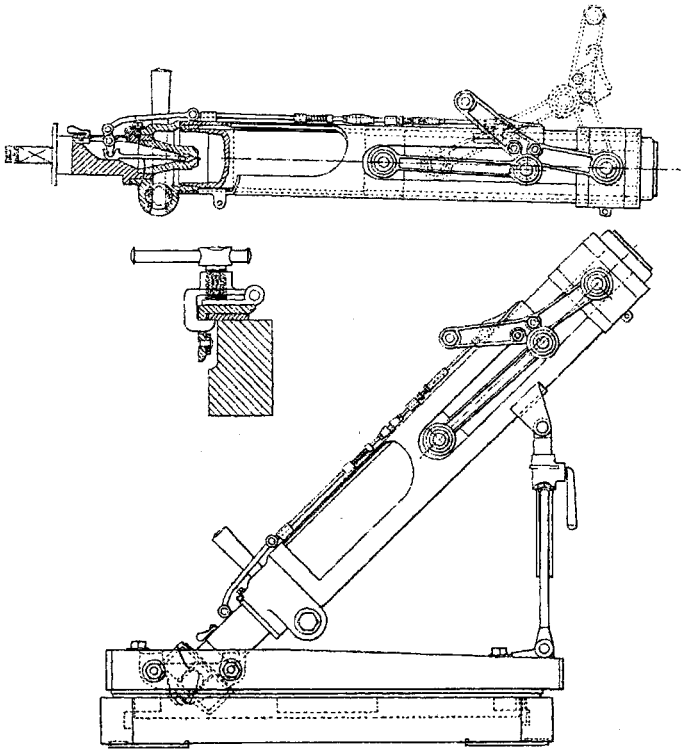
An even more complicated weapon was a magazine-fed device with a rifled barrel submitted by Captain Stanley Frederick Stokes, Royal Engineers, who was unrelated to Wilfrid Stokes of Ransomes & Rapier. This was supposed to fire shells at an incredible rate, machine-gun fashion. When Captain Stokes approached the Munitions Inventions Department in August 1915, he was unaware of the other Stokes. The captain's mortar had a



Captain Stanley Stokes's mortar in the closed firing position with one round in the breech. A loaded magazine is ready to feed its six shells into the mortar. A publicity shot from a brochure produced by Alley & MacLellan Ltd. (MUN 7/273)



Another shot from the Alley & MacLellan brochure showing the open position. The mortar weighed 209 lb not including ammunition. (MUN 7/273)



The mortar invented by Captain Stanley Stokes, RE, and the subject of UK patent 12,478. Its complexity compared with Wilfrid Stokes's mortar is easy to see.

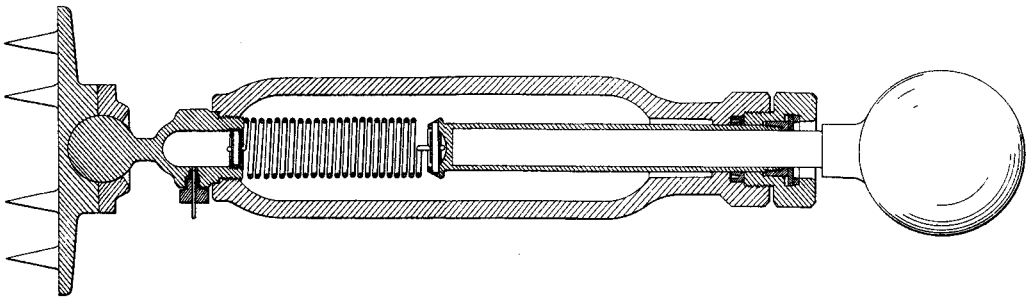
3.25 in bore and a range of 1,000 yd, firing a 10 lb shell. The department was not keen on it so Captain Stokes took it to the engineering firm of Beard & Fitch who undertook to develop it. The cost of the modifications was estimated at £100–£200. The first trial was held in November 1915, followed by another at the Grenade School, Marsden Park, Godstone on 18 December, this time with the Mk II. This second trial went badly, with a lot of misfires and jams, a shell finally bursting in the barrel so that the chamber burst. The next round fortunately misfired, otherwise a bad accident might have occurred. It was rejected on 27 January 1916.

In February Captain Stokes injured his hand, breaking a couple of fingers, while experimenting with shells for the mortar. His medical board proceedings file suggests that the weapon was being taken up but this was wishful thinking on Stokes's part who wilfully misled the board. In the meantime, showing remarkable faith in his invention, Stokes had proceeded to file patent applications in August 1915, which subsequently became UK patents 12,477/15 and 12,478/15 although they were not granted until 1919 by which time it had become rather academic. In June the New Trench Gun Syndicate obtained the patent rights. The design was modified by engineers Alley & MacLellan, the previous firm having lost patience and cut their loses. In September 1916 Alley & MacLellan spent yet more time and money perfecting the gun to fire fifty 4 in, 10 lb shells per minute. By now, the costs had escalated to over £400. It made no difference, the mortar was still rejected.

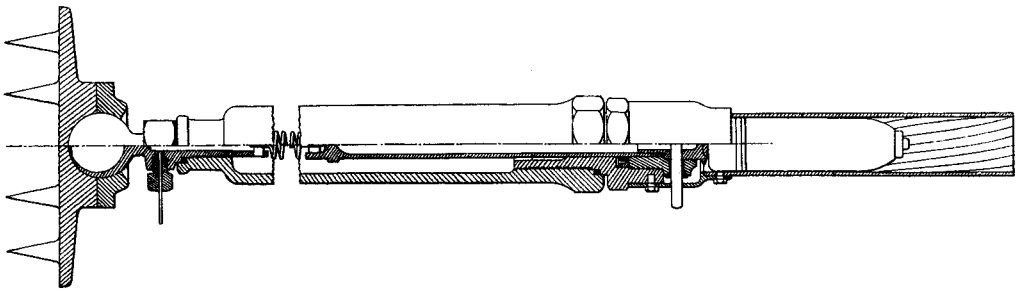
Following Captain Stokes's medical board proceedings, much to his chagrin he found he was to be posted to India and began to feel unfairly put upon by the authorities who were not in the least bit sympathetic to his cause. He returned to Chatham Barracks in September. In the meantime, his wife wrote to Lloyd George to plead her husband's case and her letter was passed to the Munitions Inventions Department who told her that the mortar had been rejected. Captain Stokes was nothing if not persistent. He never accepted any rejection as final and kept up his campaign to get his weapon accepted.

A report in January 1918 listed the mortar's shortcomings. It was not mobile enough. The parts were difficult to keep free of rust; it was highly susceptible to mud and water. It was dangerous when it jammed – the operator was liable to get his head blown off. If the striker broke, it was far from easy to replace. The mortar needed an excessive number of spares. Fouling by unburned celluloid caused misfires. It was considered highly improbable that the weapon would ever enter service. This was a polite way of rejecting a dangerous and unreliable contraption that could have caused a disproportionate number of friendly casualties.

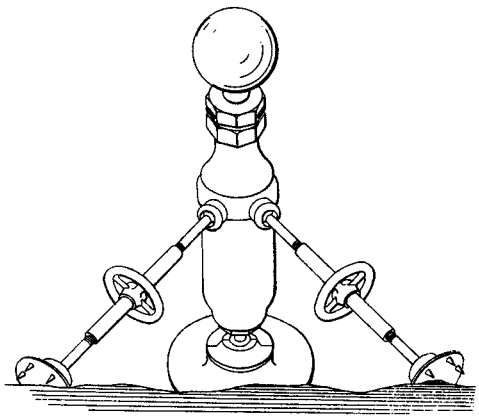
There were a number of mortars that worked on the principles of expanding liquids, i.e. hydraulic mortars. Gogu Constantinesco, a Rumanian engineer, and W. Haddon, both of the Haddon Engineering Works in Alperton, Middlesex, devised such a mortar and filed a patent application on 19 June 1916. This was eventually granted as UK patent 16,280. At about the same time, Constantinesco was in the process of designing a hydraulic interrupter gear for aircraft machine-guns to enable them to be fired through the propeller without shooting the propeller to pieces. This was based on one of his earlier inventions, a hydraulic drill used in



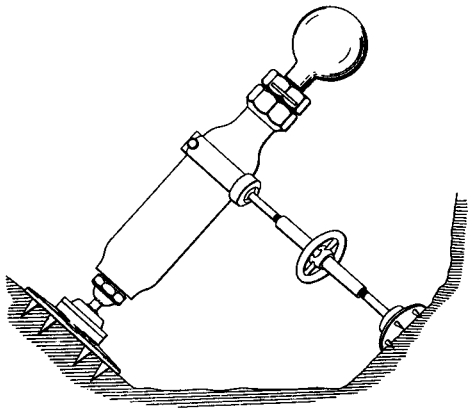
Gogu Constantinesco invented this hydraulic mortar (UK patent 16,280) in 1916. This drawing illustrates one embodiment for firing toffee-apple rounds. Note the fluid chamber at the breech.



Another embodiment of Constantinesco's invention showing a rifled barrel for firing 75 mm shells.



Constantinesco's mortar ready for firing. Note the legs and elevating gear.



Side view of the hydraulic mortar.

mining. The interrupter gear entered service in 1917 and was in general use by the end of the war. The interrupter gear eventually won him an award from the Royal Commission on Awards to Inventors. With J.R. Middleton, he filed a second patent application for another mortar in March 1917 which was granted as UK patent 128,595 but the piston in this one was operated by explosion of a propellant.

He was not so fortunate with his mortars as he was with his interrupter gear. They were both rejected by the Munitions Inventions Department. The truth was that irrespective of any merits in its favour, a hydraulic mortar was not a practical weapon for the trenches. It was an ingenious device, and no doubt Constantinesco was an expert when it came to hydraulics, but his mortar was too complex and would have required specialist equipment and personnel to maintain it. The one described in UK patent 16,280 was intended to fire 75 mm artillery shells. It consisted of a cylinder, mounted on a ball joint, in which was a piston that was drawn back towards the base by a powerful spring. A rifled barrel was mounted on the mouth of the cylinder and a shear pin or disc at the mouth held the piston in a cocked position. The shell was inserted in the barrel and the head of the piston abutted the base of the shell. A chamber at the bottom of the cylinder and below the spring was pumped full of liquid (water or oil), the pressure rising until it reached the correct level, shearing the pin and allowing the piston to propel the shell up the barrel. A major disadvantage of the hydraulic mortar was the necessity of pumping the liquid which would have required a lot of hard work on the part of the operator. It would not have been popular with mortar crews.

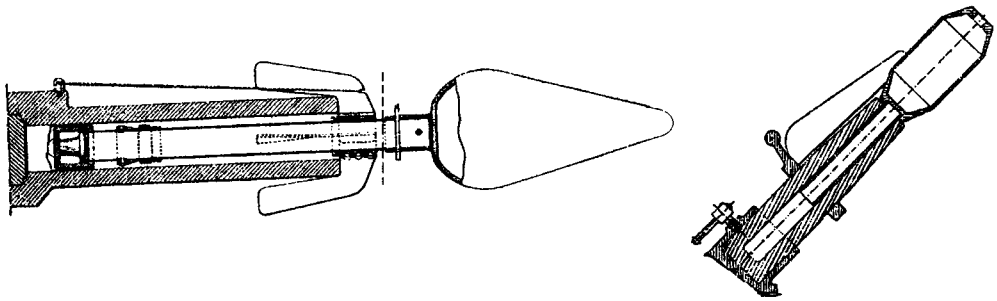
Some mortars were operated by compressed air. The Germans copied a French compressed air mortar. A 105 mm model fired finned projectiles to about 2,500 yd. A regulator was used to adjust the pressure and therefore the range. The Germans also used a 150 mm model. Compressed air mortars may have been silent, as were hydraulic mortars, but they were technically more complex than conventional mortars and required skilled operators specially trained in their use. The problem of noise and flash occupied the minds of many inventors and various noise reduction devices that could be fitted to mortars were invented but none of them seem to have been really effective or practical. Some were given trials and a Temple device was fitted to the 2 in toffee-apple mortar.

The Brandt pneumatic mortar with compressed air cylinder photographed in August 1918. Someone has lodged a shell in the muzzle, presumably for effect, although it appears to be about to fall out. Note the leather muzzle cap suspended from the barrel. (IWM)

Experiments were carried out with a number of heavy trench mortars including a 9.45 in version of the 6 in Newton but the mounting was not strong enough so it was abandoned. A Thornycroft mortar of the same calibre was considered. This was a modified service 9.45 in with a separate explosion chamber (as opposed to an expansion chamber) from which the propellant gases passed into the breech but it was considered to be an unnecessary complication which only added weight. Moreover, for safety reasons the chamber had to be cooled every few rounds after rapid firing before it could be reloaded. The advantage of having a separate chamber of this sort was the reduction of stress on the tail fins so that they were less prone to buckling. It was turned down.

Vickers and Armstrong Whitworth both submitted large-calibre, rifled breech-loaders which were described as 'finely made pieces of ordnance'. The Vickers had a calibre of 9.2 in while the Armstrong Whitworth was a monster of 11 in. The Armstrong Whitworth mortar was trialled but found to be no more accurate than the 9.45 in already in service and since the projectile weighed 200 lb, which was far too heavy, no further action was taken. The Vickers was not even given a trial.

The main objection to these weapons was that they were too complicated to manufacture and would divert skilled workmen from the production of artillery as well as needing skilled



Left: *E. Schneider's mortar shell with stem and fins.* Right: *UK patent 127,285, granted to the French company Soc. Anon pour l'Exploitation des Procédés Westinghouse-Leblanc. The stem is hollow so that the propellant gases do not interfere with the fins. The adjustable collar round the barrel, just below the fins, allowed range adjustments by varying the size of the combustion chamber behind the stem. The mortar was the subject of UK patent 125,413.*

artificers to maintain them in the field. Armstrong Whitworth also submitted a 10 in rifled muzzle-loaded mortar but again its accuracy was no improvement over the 9.45 in and the shell was far too heavy. It had some novel features, none of which counted in its favour since they added complication rather than providing simplicity. It was the subject of at least one patent, and possibly two (13,445/15 and 125,475). It had a separate explosion chamber and a small breech block. The opening from the chamber to the barrel was filled by a piston fitted to the base of the shell to allow the pressure to build up to the necessary pressure before projecting it from the barrel. This was just another unwanted complication.

In the end, only simple mortars interested the research departments and the Army. Despite Wilfrid Stokes's criticism of government departments making things unnecessarily complicated, every complex device was turned down.